MANGALORE UNIVERSITY

SYNOPSIS

SALT WATER INTRUSION IN TO THE COASTAL AQUIFERS IN AND AROUND MANGALORE, DAKSHINA KANNADA, KARNATAKA, USING GIS TECHNIQUES

SYNOPSIS OF THE Ph.D.,THESIS TO BE SUBMITTED TO THE FACULTY OF SCIENCE AND TECHNOLOGY MANGALORE UNIVERSITY FOR THE AWARD OF THE DEGREE OF

DOCTOR OF PHILOSOPHY
IN
GEOINFORMATICS

SUBMITTED BY

Mr. NATASHEKAR, D. M.Sc., PMDH
RESEARCH SCHOLAR
GEOINFORMATICS DIVISION

SUPERVISED BY

DR. SHIVANNA
ASSOCIATE PROFESSOR
DEPT. OF MARINE GEOLOGY
MANGALORE UNIVERSITY
MANGALAGANGOTRI – 574 199

2012

SALTWATER INTRUSION IN COASTAL AQUIFERS IN AND AROUND MANGALORE, DAKSHINA KANNADA, USING GIS TECHNIQUES

INTRODUCTION

Water is essential to all life on the earth. It is the only commodity that man is totally unable to survive without the lack of sufficient water to meet the demands of humans, livestock's and crops constituents a drought. The largest available resource of water lies underground. The importance of ground water to meet the increasing demand for domestic industrial and agricultural purpose needs careful and critical assessment of its availability and quality. The sub-surface rock strata or geographical body, which is water bearing called as aquifer. Unlike mineral and fossil fuels ground water is renewable resource.

The development, utilization and management of water resource have assumed great importance during the last few decades with the large scale industrial and agricultural development population explosion etc., demand for water is ever on the increase as the surface water resources are exhausting at an alarming rate man has turned towards tapping the ground water which is a great asset to mankind until and unless its exploitation is in a proper way. Indiscriminate extraction of ground water results in lowering of ground water table to depths of more than 100 meters below normal.

Ground water is prone to another threat in the coastal aquifers other than anthropogenic and natural contamination, which is seawater intrusion in to these aquifers invasion of saline water in to fresh ground water due to ground water withdrawal commonly occurs in coastal aquifers, where sea water moves in land if ground water levels decline, salt water can also move upward in to fresh ground water in aquifers underlain by saline water. When water is pumped from wells that are too

close to the fresh water - salt water interface the salt water beneath the well rise and enter the well this phenomenon is called up coning.

In the study area the largest quantity of fresh water available for multipurpose is sub-surface water. Its quality is as important as its quantity. The large quantities of water in the aquifers are generally free from excessive contamination that causes concern. In an aquifer with a sea front there is direct contact between continental fresh water and marine salt water. Besides on account of the difference in viscosity between the two fluids, there exists a density change that depends mainly on salinity differences. In a stable system fresh water floats on the salt water and a land water sloping interface exists between them. The salty 'ground water body adopts the form of a wedge resting on the aquifer below (Todd, 1980). The freshwater thickness decreases from the wedge towards the sea (custodo 1987, Charbeneau 2000, Kim et al., 2004, Park et al., 2005, Lee and Song, 2007, Ranjan 2007).

PRESENT STUDY

The present study area comprises of wells sunk in process soil which are shallow and which get filled to the brim in rainy season. Some over ambitious farmers deepens the well to get good yield & strike the interface between the fresh water & salt water. This is also one of the reasons for the salt water intrusion in coastal areas.

The present study area lies between 12° 45' , 13° 0' latitude and. 74° 47' & 75° 0' East longitude (Ref: Survey of India Toposheet No. 48, L/13). This stretch of land covers area of about 600 sq.km extending from Talapady in the South east to Surathkal in the North West.

PREVIOUS WORKS

Narayana and Suresh (1989) determined the chemical quality of ground water of Mangalore city, Karnataka. Fifty six samples of ground water were analysed for P^H, specific conductance, hardness, Na, K, Ca, Mg, Cl^-, HCO_3 and SO_4. Most of these chemical parameters are correlated with one another. The study reveals (i) Na- Ca- Cl. (ii) Na-Ca-HCO_3 (iii) Na-Ca-Cl-HCO_3 and (iv) Ca-Mg-Cl types of ground waters and two distinct ground water zones namely Na-Ca-Cl and Na-Ca-HCO_3 in Mangalore. Saline water incursion in the southern, western and north western parts of Mangalore indicates over exploitation of ground water. They suggested that measures have to be taken to avoid further deterioration in the quality of groundwater.

Suresh (1994) determined major cations and anions of groundwater from open wells of Mangalore city, Karnataka, have been analyzed to understand the water- rock interaction and human interface in coastal lateritic terrain which receives very high rainfall (3300mma-1). Geology of the area is highly dissected, literalized pebble- gravel beds, which were deposited under rising sea-level during the Mio-Pliocene transgression. Most of the wells are situated in the active circulation zone with a very high flow rate. Ground waters of the terrain have low concentrations of total dissolved solids (TDS) and they can be grouped into two categories: dilute (100ppm TDS) and moderate (100-400ppm TDS). These groups possess different characteristics with respect to elemental concentration. TDS show good correlation with conductivity (r =0.914) with a slope of 0.599 per unit, which is low when compared to the terrains. Two samples collected from bore wells show low conductivity values and they have considerable magnesium, probably derived from the basic igneous rocks (dolerite dykes).

Chemical classification reveals that the majority of the samples are Na-Ca-Cl and Na-Ca-Cl-HCO_3 types with Na and Ca in nearly equal

amounts. Potassium occurs in considerable amount exceeding sodium in a few samples. Bicarbonates exceed chloride in weight percent sulphate occurs in trace amounts in majority of samples, but a few samples have high values (upto 69ppm) and this is attributed to anthropogenic source since sulphate shows no correlation with other ions and he suggested that topography has a strong control over the distribution of ions. Na-Ca-Cl type waters predominate in the elevated places and slopes of the terrain and Na-Ca-Cl-HCO_3 in low lying areas. It appears that the area fringing the estuaries is experiencing saline water incursion and chemical constituents present in the municipal drainage do not simply move into the estuaries, but instead spread into the adjoining litho units of low lying areas under the influence of tides. Data have been statistically treated to compare/ differentiate the various sources of major ions. Ion ratios and possible water rock interactions have been discussed.

Rajesh et al., (2002) have demonstrated the utility of multivariate statistical techniques in hydro geochemical studies for the Nethravathi river basin using more than 50 samples. Similarly, Rajesh et al., (2001) have elaborated the spatial distribution of P^H, EC and total dissolved solids for 34 open-well and 22 bore-well samples of the Nethravathi river basin. The study focused on the pollution of groundwater due to saltwater ingression along the river. They have also suggested that the pH range to be excess of the WHO or ISI limits for the samples under study. Also, Rajesh et al., (1999) have evaluated the aquifer parameters for the nethravathi river basin and have generated thematic maps depicting the transmissivity, storage coefficient, etc and have give a graphic description of the variations in the spatial sense. Rajesh et al., (2000) have carried out a quantitative study of nethravathi river basin and have estimated the annual groundwater draft to be 404.81 M CuM.

AIMS AND OBJECTIVES OF PRESENT STUDY

For efficient planning and management in coastal aquifers it is essential to decipher and assess the extent of intrusion of salt water into the aquifer, Vis-a Vis variations in the components of the fresh water. The Mangalore coast is affected by this problem and hence an attempt has been made in this work to analyze the situation.

The present investigation aims at the following aspects

- To study the extent of the problem of the salt water intrusion in the coastal aquifer in the study area using hydrological techniques.
- Identification of salt water intrusion in to the coastal aquifers using GIS techniques.
- To assess the geological, geomorphological, hydrogeomorphological factors responsible for the landward seawater encroachment.
- To propose possible sustainable water management practice to limit sea water intrusion and remedial measures as an outcome of the research work

Organization of chapters: The thesis comprises seven chapters which are as fallows:

Chapter 1 deals with the general introduction, general features of study area, (climate, physiography, etc.) previous work of the research topic.

Chapter 2 describes general information about remote sensing and GIS. Remote sensing and GIS techniques have been used to understand the geomorphology and spatial distribution of various land use/land cover features of the study area. Thematic map has been generated with supervised classification using Knowledge Tree techniques have aided in deciphering the aerial distribution of land use/ land cover classes.

Ground truth data like industrial area, water body, agricultural plantations, river, river island, barren rock and marshy area of field photographs has been collected to appreciate the land use/land cover features of the classified imagery. Thus, the remotely sensed data too is suggested to be of immense aid in mapping, monitoring and management of natural water resources.

Chapter 3 describes general information about the geology of India, Karnataka, describes about the study areas geological formations, rock types etc. An important geological phenomenon the southwest coast of India experienced during tertiary and quarternary period was lateritisation. The thickness of the laterite zone is considered to be proportional to the zone of fluctuation of the water- table (Marbut, 1932).

Outcrops of well developed laterites occur at many places along the coastal zone of the area, they occur as discontinuous ridges and plateaus. Field studies reveal that the geology is also a main controlling factor for ground water quality.

Chapter 4 provides hydrometeorology of the study area; it includes rainfall data, graphs of the selected stations, isohytal map, Water demand calculations of Mangalore industries.

In view of increasing demand of water for various purposes like agricultural, domestic, industrial etc., a greater emphasis is being laid for a planned and optimal utilization of water resources. Due to uneven distribution of rainfall both in time and space, the surface water resources are unevenly distributed. Rainfall data and its graphs have been generated to understand the average rainfall distribution of both post monsoon and pre-monsoon seasons of 13 years that is from 1993-2008.

Chapter 5 forms the backbone of this work; it provides information about hydro geochemistry of the study area. Interpretation of maps like total dissolved solids, electrical conductivity, ph are briefly discussed to know about the extent of saltwater intrusion in the study area. Maps are represented to show the intrusion of saltwater.

Using computer programme-HYCH various water quality parameters have been determined and spatial distribution maps prepared by using GIS techniques for both post monsoon and pre-monsoon seasons and discussed (salinity sodium hazard, Index of Base Exchange, water type, Corrossivity ratio, Ground water hardness, Schollers type etc.). The precipitation pattern in the area also seems to be a controlling factor in the overall chemical quality of the area. Index of Base Exchange and ground water types indicate that the waters of this area have stayed for time in the aquifers to get modified to the present quality due to rock-water interaction.

Chapter 6 deals with the general introduction on salt water intrusion, ground water and coastal ecosystem, physical characteristics of sea water intrusion, other causes of salinity increase in ground water within a coastal area, recognition of sea water in ground water, ground water status of the area, prevention and control of sea water intrusion, methods for controlling or preventing sea water intrusion, pollution of ground water and its causes with remedies and remedial measures and recommendations of the area.

Finally chapter 7 concludes the thesis by giving the results arrived through this work.

References

Charbeneau, R.J. 2000. Groundwater Hydraulics and Pollutant Transport. Prentice Hall, Upper Saddle River, New Jersy, pp 593.

Custodio, E., Bruggemen, G. A. and Cotecchia, V.1987. Groundwater problems in coastal areas, Studies and Reports in Hydrology, vol.35, UNESCO, Paris.

Kim, K., Rajmohan, N., Kim, H.J., Hwang, G.S. and Cho M.J.. 2004. Assessment of groundwater chemistry in a coastal region (Kunsan, Korea) having complex contaminant sources: a stoichiometric approach. Environmental Geology. 46: 763–774.

Lee, J.Y. and Song, S.H. 2007. Evaluation of groundwater quality in coastal areas: implications for sustainable agriculture. Environmental Geology. 52: 1231–1242.

Marbut, C.F. 1932. Morphology of laterites. Proc., Intl. Soil sci. Congr. 2nd , Moscow, vol.5, pp.72-80.

Narayana, A.C. and Suresh, G.C. 1989. Chemical Quality of Ground Water of Mangalore City, Karnataka. Indian J. environs Hlth, Vol. 31, No. 3, 228-236.

Park, S.C., Yun, S.T., Chae, G.T., Yoo I.S., Shin, K.S., Heo, C.H. and Lee, S.K. 2005. Regional hydrochemical study on salinization of coastal aquifers, western coastal area of South Korea. Journal of Hydrology. 313: 182–194.

Rajesh Reghunath., Sreedhara Murthy, T.R and Raghavan, B.R. 1999. Aquifer Parameter Evaluation of Nethravathi Basin, Karnataka State, India. Journal of Applied Hydrology Vol. XII, No. 1, pp.46-51.

Rajesh Reghunath., Sreedhara Murthy, T.R.and Raghavan, B.R. 2000. Ground Water Potential of Nethravathi River Basin, Karnataka State, India, Second Convention of the Mineralogical Society of India and National Seminar on Earth Resources.

Rajesh Reghunath., Sreedhara Murthy, T.R.and Raghavan, B.R. 2001. Spatial distribution of pH, electrical conductivity and total

dissolved solids of groundwater of Nethravathi River Basin, Karnataka State, India poll Res. 20(3): 413-415.

Rajesh Reghunath., Sreedhara Murthy, T.R.and Raghavan, B.R. 2002. The utility of multivariate statistical techniques in hydro geochemical studies: an example from Karnataka, India water research 36, 2437-2442.

Ranjan Priyantha. 2007. Effect of climatic change and land use change on saltwater intrusion. Retrieved on February 13, 2008 from http:// w.w.w.eoearth.Org/article/Effect_of_climatic_change_and_land_use_ change_on_saltwater_intrusion.

Suresh, G.C. 1994. Major Ion Chemistry of Groundwater of a Coastal Lateritic Terrain an analysis of Mangalore City Groundwater. Natl. Symp. On Applied Geochemistry Univ. Madras P. 79

Todd, D.K. 1980. Groundwater Hydrology. Second edition. John Wiley and sons.

RESEARCH SCHOLAR RESEARCH GUIDE